Capturing Complex Business Processes Interdependencies Using Modeling and Simulation in a Multi-actor Environment

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Abstract. Current business processes tend to become increasingly complex as a result of extensive interdependencies with partner organizations and the increasing use of technology for decision making in multi-actor environments. This complexity often grows to the extent that none of the involved actors is able to have a total overview of the complete end-to-end processes. An example of such a complex process is the application process of new merchants to obtain the possibility to accept electronic payments. Although static modeling of such a process can reveal valuable information about the structure and organization of business processes and the relation with the involved actors, a simulation model can provide more insight into behavior of the business system. With this knowledge the possible bottlenecks and problems within this process can be found, and then used to improve the business system resulting in an improved customer satisfaction. This paper describes the set-up of this simulation model and its use for finding efficient policy measures for involved actors.

Keywords: Animation, visualization, business process complexity, complex business process, multi-actor system, actors interdependency, business processes modeling, business process simulation, discrete event simulation.

1 Introduction

Nowadays business processes are often taking place in complex technological environments and multi-partner settings, where the business processes are for a large part depending on the performance of the underlying technology and relationship between the partners (Mintzberg, 1981). Since this technology is not always at hand within the organization that needs it, the outsourcing of technological solutions is becoming a standard way of working. For an outsourcing solution to work, access to external databases and feedback loops are often needed, which makes it crucial that computers can always interconnect in real-time after the architecture is finalized (Kaufmann & Kumar, 2008). The technological architecture does not stop at the organizational boundary and it enables interactions with customers and other businesses. In this way a complex constellation consisting of many different actors is created. These actors have

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to cooperate with each other in order to make the processes work as intended. The performance of the complete process is dependent on the weakest link (Janssen, 2007). Therefore we need to analyze this problem on a network level and take the activities of the various actors into account. Only in this way the full, interconnected system can be analyzed. This means that information sharing between the actors of the subsystems should be maximized during the analysis or design of such a business system, since this increases the understanding of events within the inter-organizational processes and it improves the efficiency of decision making (Baffo et al., 2008).

On the level of a single organization this information often is the factor providing strategic advantage for companies, so the willingness to share this information will be low. Also the responsibilities of the individual companies just entail parts of the system, so their perspectives will differ from a holistic picture of the system and of the perspective of other actors. Therefore while the individual companies have a strong incentive to optimize their own organizational performance, they might not have incentives to further improve the overall system and its performance. Sometimes the perspectives are conflicting and optimization within one individual company will lead to a worsened system performance or undesired impacts elsewhere down in the process chain. Furthermore, the one who is paying for the investments might not be the beneficiary.

These types of complex multi-actor systems are difficult to analyze and possibilities for policy measures to solve the problems within these systems are therefore difficult to find. On top of it, trying to find policy measures from trial and error is often not possible, especially since the implementation of policy measures in one company could bring along unpredicted and sometimes unwanted results in the whole system and influence some of the other involved actors. An example of such a system in which the involved actors are both technically and organizationally interdependent is the electronic payment sector in the Netherlands. In the past the electronic payments sector was dominated by one party who intermediated all transactions among banks and businesses. There were many complaints about the costs for the merchants, and the Netherlands Competition Authority decided that this was an undesirable situation and it decided to reduce the monopoly position. The competition authority decided to introduce competition by splitting up the system into independent subsystems. Each subsystem should be provided by a number of providers, in this way stimulating competition. Thereby the influence of the end customer has also been increased since the customers can decide to choose a certain service provider. As a result the companies within the chain will have incentives to operate in a more efficient way, providing the end customer with higher quality products which costs less (Koppenjan, 2008).

When an individual company in a complex network wants to optimize system performance, it is very difficult for this company to analyze which policy measures will have an effect and what the exact effects will be. If a company in the investigated electronic payment system wants to increase the satisfaction for the end customer by enlarging the efficiency of the application process for merchants, it is difficult to predict whether a policy measure taken in his company will lead to less throughput time and less responsibilities and tasks for the merchant.

A popular method of analyzing complex and uncertain situation is using modeling and simulation (Carson, 2003). By analyzing the current situation with modeling and simulation tools, possible policy measures that will improve the system performance can be identified and quantitatively analyzed. In addition, by using the models in a strategic workshop, it will be possible to analyze the power structure within the business system and find the points where strategic behavior is possible, so the initiating company can take this behavior into account when making decisions about policy measures. This will be elaborated in the third section.

This paper reports a case study that involves a complex business setting. The main objective of this study is to investigate the possibilities to achieve system performance improvement in this multi-actor environment, by using the minimization of the throughput time of the business system as an assessment criterion. The study is carried out with a combined modeling and simulation method. This paper discusses mainly the static and dynamic modeling stage of the research and some first results of the modeling process.

2 Case: Electronic Payments Sector

In the case of the electronic payments sector, we have observed different objectives and different wishes (motivations) for making changes in the business system with different actors. Differences like this often lead to conflicting requirements for the business system and create a lot of confusion for the involved actors. This results in a situation in which multi-actor decision making is needed to solve the conflicts between the involved actors. The outcome of these types of decision making is often a situation in which all involved actors achieve parts of their goals but also have to give up some of their wishes. The final solution might focus just on the technical level, and lead to a situation in which the optimal business system performance will not be possible as a result of the many interfaces that are needed and the many points where mistakes can be made (Han et al., 2008). If this system is then put in operation, the result is often that the subsystems which are independently managed are not optimized for interacting with each other. This becomes especially visible for the end customer who might experience the mistakes when interactions among the subsystems fail. The problem is that this end customer does not have any knowledge on the cause of the problems. When the merchant discovers the causes of the problems, he is not in the position to handle the problem. When confronted with a problem from an end-customer in a complex network, companies often blame each other and do not provide a solution for the whole system as a solution goes beyond their organizational boundaries. Since within the chain there is no single actor that has the overview of the whole system, the involved actors will also not always be able to identify the cause of a problem. These types of situations are very difficult to handle, since the optimal solution is not easy to find (Sage, 2008). This could be due to for example that the considered causes of problems could be the wrong ones, or that the optimal system performance cannot be reached within the existing boundaries and requirements, even if the cause is known. This could lead to a situation in which the performance criteria are difficult to measure and the involved actors end up in a power struggle and arguing on responsibilities with each other. To improve the general system performance, the causes for problems and bottlenecks should be found, and arrangements should be made to prevent the power struggle and introduce performance measures to efficiently arrange the processes (Koppenjan & Groenewegen, 2005).

This case study is limited to the application process that is needed to acquire a working payment terminal to accept electronic payments. This system has technical complexity because of the interdependency between the technical systems, and organizational complexity since information sharing is needed for the system to perform. Also the competition authorities have introduced measures for competitiveness within the system to maximize the choice possibilities for the merchant. The process is analyzed from the viewpoint of the end customer, the merchant, and it contains the actions and events that have to be carried out before the terminal in the shop is operational.

In Figure 1, the application process is illustrated in a high level system diagram. As shown in Figure 1, the goal of the merchant is to have an efficient application process. This can be measured by a low throughput time of the application process, and few responsibilities for the merchant within the application process. This translates into the merchant requiring a short period of time between the time sending in a request for a new terminal and the moment when he has a working terminal within his shop, and a number of tasks for the merchant to be performed during the application process that is as low as possible. This means, less time is needed between an inquiry and the installation of the new terminal and simplified working process for merchant.

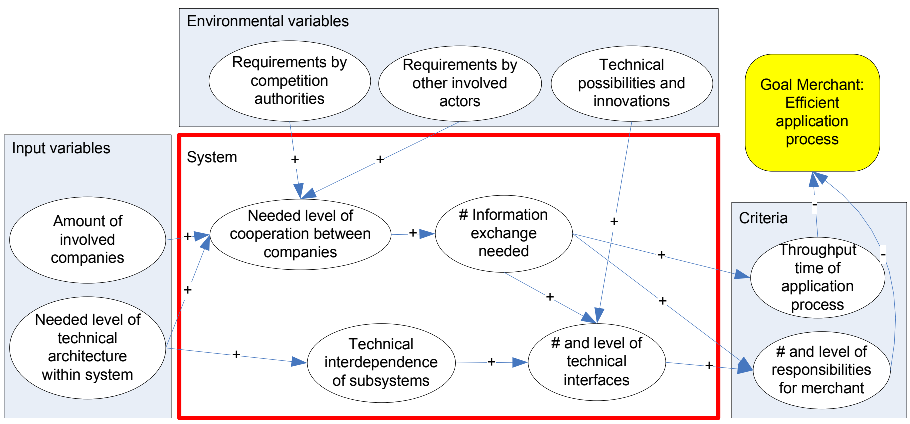

Fig. 1. System diagram for application process of merchants

The environmental variables in this system are the requirements set up by competition authorities in the form of regulation, requirements by other involved actors in the form of agreements, and the technical possibilities and innovations available at this moment. To fully maximize competition, the merchant should have fully independent choice possibility within the entire system. The other involved actors have set requirements to elements within the cards acquiring process and to let the system work. The technical possibilities and innovations currently enable the terminals to communicate with the acquiring processors over fast internet connections, both fixed and mobile. The term ‘acquiring processors’ refer to the non-bank service firms that handle electronic transactions of the customers, also called merchants, of an acquiring bank. Also it is technically possible for involved parties to update information into the acquiring processors' systems and databases in real-time making it possible to directly view the results of the updates. The input variables for this system are the number of involved parties within the application process and the level of the technical architecture within the system.

This case study provides an good example of modeling and simulation tools used in a complex multi-actor environment with technological interdependencies to provide more insight into the business processes and possibilities for improvement. As mentioned earlier, modeling and simulation enable actors to detect errors and potential problems within a business system in a cost effective manner (Ghosh, 2002). Especially for this case study for the identification of the relevant business processes, and the link to the operational performance of these business processes to strategic policy measures, a simulation model can be very helpful. (Greasly, 2000)

The crucial role of modeling within this research is to document the business processes as much as possible in a visualized way, to enable different parties to gain insight into the complexity and the potential solutions. For these reasons business process modeling of this system is conducted using rich graphical notations and diagrammatic languages. Creation or construction of business process models can help us to understand business processes, the actors involved, and to see the interdependencies between actors and complexity of processes (Shannon, 1998). For modeling to provide true value in this complex system, it is needed to look at the time-ordered dynamic behavior of the system. In this regard simulation plays a complementary role in understanding and analyzing complex systems (Zeigler et al, 2000). Simulation is a powerful tool for the analysis of new system designs, retrofits to existing systems and proposed changes to operational rules (Carson, 2003).

Currently there are five types of actors, including the merchant, who are crucial for making the application possible, and there is competition between actors for the major part of the system. On the technical level there is a need for communication between three of the five crucial parties to make the application possible. In Figure 2, the critical actors within the application process are shown. The merchant should provide information about his application choices to the terminal supplier, the acquirer and the telecom supplier. Then the application information is processed by the terminal supplier and the acquirer into the databases of the acquirer system. In addition to this, the application information should be inputted using the terminal. When the terminal and the databases of the acquiring processor contain the same information, the terminal can start accepting electronic payments. To achieve this, the terminal has to be able to communicate on a periodic basis with the acquiring system and the terminal management system through a telecom connection. The information exchange and the technical connections are also illustrated in Figure 2.

As shown in Figure 2, there are many moments when information exchange is needed between the involved actors. Since this information exchange occurs in a sequential order, it is important to know at what moment in the process which information exchange takes place. There are many possibilities for merchants to go through this process; therefore in this paper the situation for a very basic configuration of the application process will be further analyzed by a model of the process steps. Possible existing variations to this process (e.g. cooperation between certain

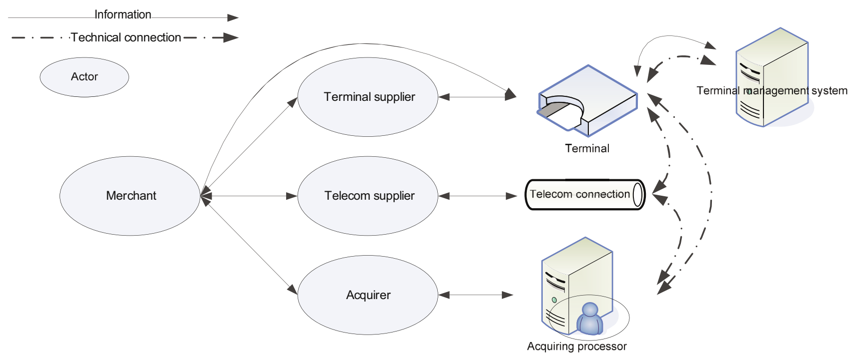

Fig. 2. Critical actors within the application process and their interaction

actors or added complexity as a result of coupled peripheral systems or internal networks) are not included in this. The results of the static and dynamic modelling of this basic application process are shown in sections 3 and 4.

3 Static Model of the Process Steps

The process starts with the merchant who wants to apply for a new terminal. As can be seen in Figure 2, the merchant should contact three parties, namely the acquirer, the terminal supplier and the telecom supplier. Basically the application processes can be carried out in parallel. The only restriction is that for the application of the acquirer the terminal IDs are needed. Therefore, the merchant first contacts the telecom supplier, and waits for the confirmation that the telecom supplier has activated a new telecom connection. Parallel to this the merchant contacts the terminal supplier. After the terminal supplier receives the application, the terminal supplier will then assign the IDs for the new terminals. Then the terminal supplier will send the terminal IDs and the terminal to the merchant. After the merchant has received the terminal, and has a confirmation that the telecom connection has successfully been set-up, the merchant can connect the terminal to the telecom connection. After the merchant received the terminal IDs, the terminal IDs can be entered into the application form of the acquirer and sent. The acquirer will handle the application forms they receive by inputting the information about the contract and about the terminal into the acquiring system. This information is needed for the acceptance of payments to be made on the terminal. After the acquirer has finished with this input, a letter is automatically generated and sent as a confirmation to the merchant. The parameters in this letter are needed by the merchant as input into the terminal. When the parameters in the terminal and the databases of the acquiring processor are matching, the terminal will be able to accept electronic payments. Also the terminal will update the terminal management system of the terminal supplier.

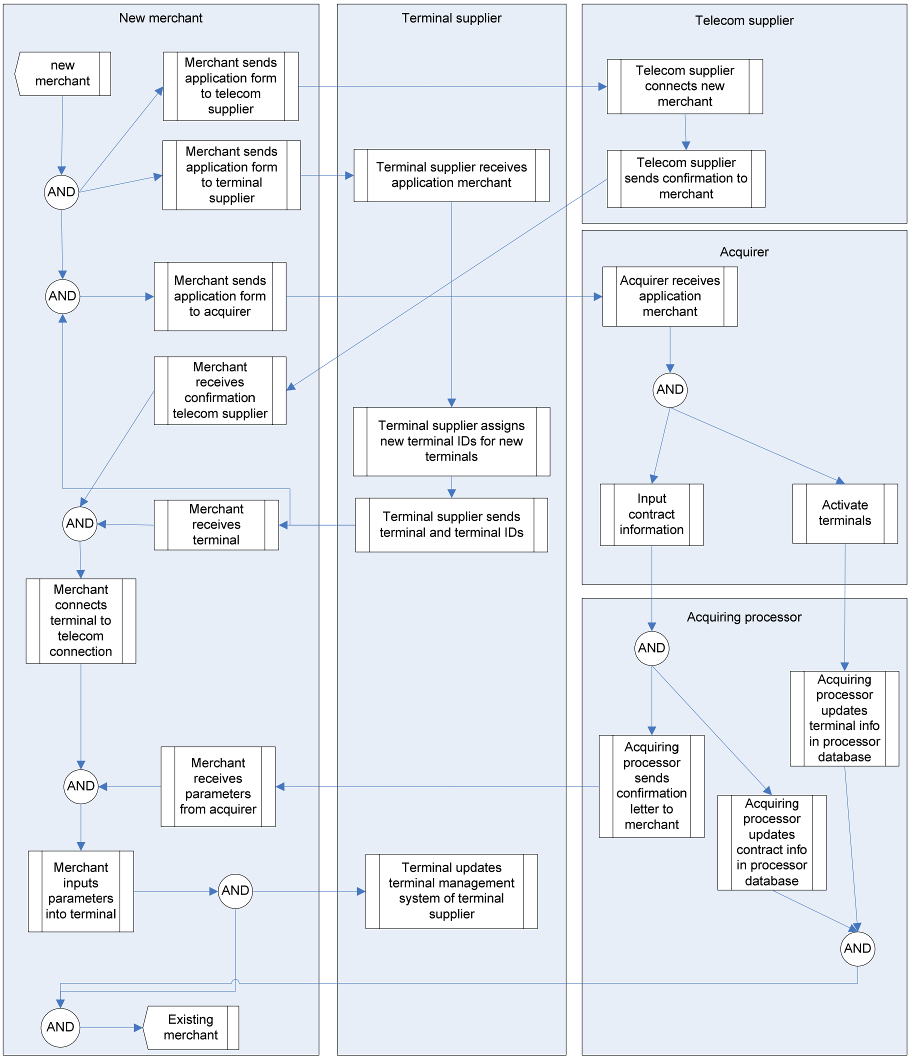

Fig. 3. Static model of application process for new merchants

It can be concluded that for a merchant to get a working terminal, there are multiple steps to complete and multiple tasks to perform. To perform the tasks the merchant is dependent on the performance of the other actors, especially for the provision of the information. From the static overview it becomes clear that there is a sequence in which the actions should take place, but it is not clear whether the moment the information needed by the merchant and the moment the information is provided to the merchant are corresponding. Also it is not clear whether the timing of information flows within the process between the other involved actors is optimal based on a static analysis.

4 Dynamic Model of the Process Steps

A dynamic model of the application process is made with the Arena software package (Kelton et al., 2002) to create an overview of the complex multi-actor system showing the time-ordered dynamics. In Figure 4, a screenshot of the model is shown, in which the application process of one merchant is analyzed with the estimated duration values for the times of the processes. This means for example for the package service, a value of one day is used, and for the update of information into the acquiring processor database a value of one hour is used. It should be mentioned that the values are not representing the actual values in the current situation, since between the different acquirers, terminal suppliers and telecom connection types there is such a variety of different values, it would involve too much data-analysis for this phase of the analysis. The model as it is only indicates the dynamic dependencies of the processes that are needed for the application processes, and do not yet contain the *exact* data for a quantitative analysis. This means that the outcomes provide a first indication based on estimates, which might not be applicable for each combination of actors. They do, however, provide a first insight into the dependencies and dynamics of the application process.

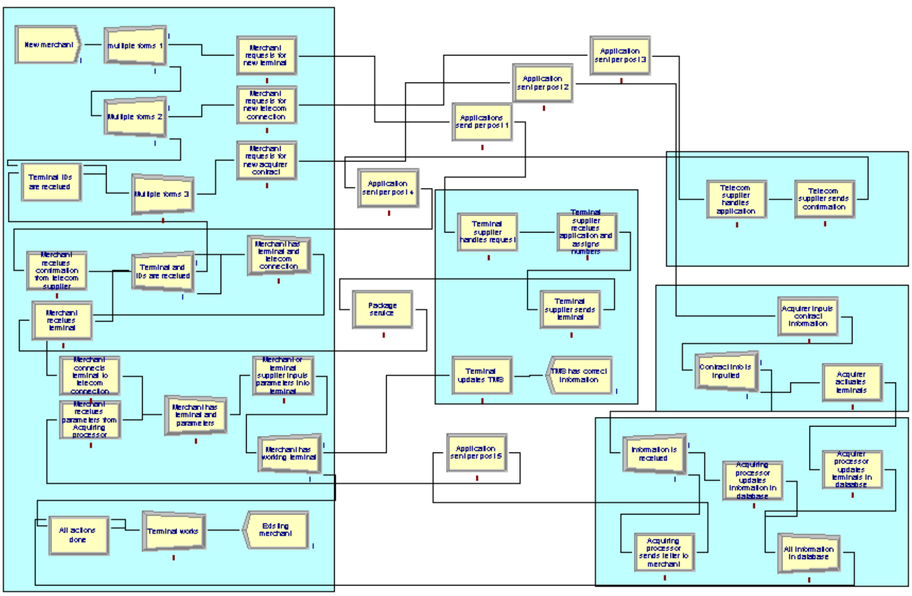

Fig. 4. Dynamic model of application process for new merchants (screenshot)

When running the simulation, it is observed that within the tasks for the merchant, there are four major points which may cause delays.

1. When the merchant waits for the terminal IDs, the merchant is not able to send in his application to the acquirer. In the current simulation it shows that this waiting time might take up to 145 hours.

2. When the merchant needs both the terminal and telecom connection, to connect the terminal to the telecom connection, a 24 hours delay may occur.
3. When the merchant has a terminal with telecom connection, and needs the parameters from the acquirer as input for the terminal, waiting time could be up to 25 hours.
4. The last point is when the data is already updated in the acquiring processor, but not yet manually inputted into the terminal. This again takes 25 hours.

Again, it should be mentioned that the values simulated (mentioned) are only to be considered as indications, resulting from the generic input values, and are not absolute outcomes. However, some first conclusions can be drawn from this dynamic model.

It can be assumed that the three actors delivering direct service to the merchant receive incentives from the merchant to optimize system performance. From the simulation model it can also be concluded that within this system it is very difficult, if not impossible, for an individual company to implement policy measures which will improve the system performance, since all actors involved need the cooperation of other actors to achieve a better situation for the end customer. This suggests that agreements between multiple parties could lead to a better situation for the end customer. The points within the system where cooperation is needed between actors are illustrated in Figure 5.

From the acquirer's perspective, it can also be assumed that the acquirer has interest in a low throughput time from the point the contract is received from the merchant to the moment the terminal can start accepting electronic payments. As can be learned from the simulation, it is then important for the acquirer that the acquiring system updates the information of the new merchant before the merchant has had the chance to input the parameters into the terminal. In addition, it can be seen that for the acquirer it is important that the merchant receives the terminal IDs as soon as possible after the application for new terminals has been sent to the terminal supplier, since that is the moment when the merchant can fill in the forms needed for the acquirer contract.

For the perspective of the terminal supplier, it is clear that it is important that the acquirer sends the parameters that the merchant should input in his terminal as soon as possible to the merchant. This is important for the terminal supplier who input the terminals on behalf of the merchants, so they can do this as soon as possible, most preferable at the same moment the terminal is delivered, which reduces their operational costs. Another important point for the terminal supplier is that the telecom connection is activated successfully before the terminal is delivered. This is equally important for some of the terminal suppliers that install the terminals for the merchants, since the telecom connection might be needed to input the parameters.

Based on the static and dynamic analysis, the involved actors within the application process can be divided into two groups. On the one hand we have the acquirer and the telecom supplier, and on the other hand the other parties, including the merchant. Within the current configuration of processes, the acquirer and the telecom supplier will have a strategic advantage, since the other actors have an interest in their cooperation. The acquirer and terminal supplier are the actors who rely the most on the other actors for a good system performance. What also can be concluded is that since the acquirer and terminal supplier are mutually dependent on each other for a good performance, this offers an opportunity to restructure the process in such a way

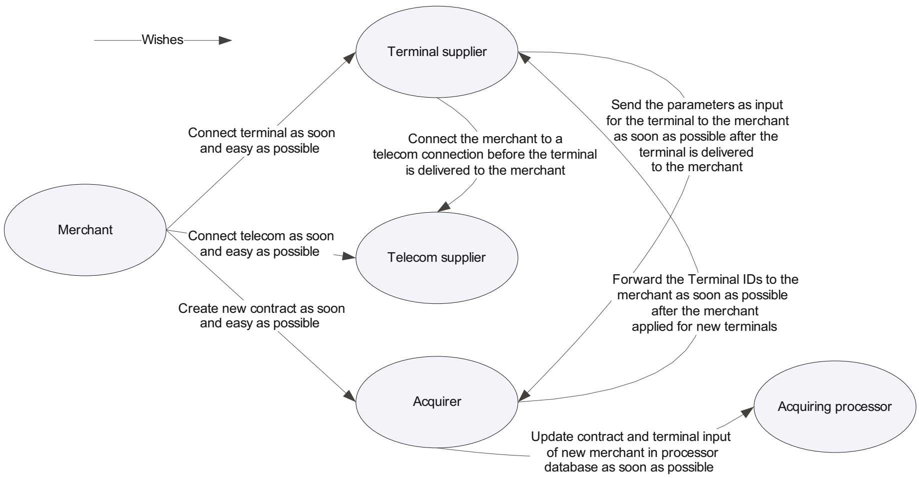

Fig. 5. Possible wishes (improvements) between involved actors

that both parties can find advantages. Since both actors will have an interest in this cooperation, this could be the most feasible way to improve the system performance.

5 Conclusion

In a more network focused economy, actors become more dependent on each other. These dependencies easily result in business failure, which needs to be analyzed beyond the individual organizational boundaries. In this paper, using an example from the electronic payments sector, it was demonstrated how modeling and simulation tools can be effectively used to find policy measures in multi-actor environments with technological interdependencies. The simulation models shows that there are many policy measures possible for improving business system performance, for example, a shorter throughput time to achieve better customers' satisfaction. Using the static and dynamic models, it can be concluded that when one company optimizes their own business processes, this might be suboptimal and will not immediately result in a better total system performance. There are two actors within the application process which are strongly dependent on each other, namely the acquirer and the terminal supplier. If one of these two companies wants to implement policy measures, it is crucial for them to make good arrangements with each other to obtain an improvement in the total system performance. Since they are so strongly interdependent, finding cooperation possibilities within the chain of actors that will lead to minimal strategic behavior from one of the actors has the most chance of success. In this system a restructuring of the application process by cooperation between the acquirer and terminal supplier could significantly reduce the throughput time. For the performance of the system, the acquirer and the terminal supplier still stay dependent on the other two actors in the process, namely the acquiring processor and the telecom supplier, to work along. Since the latter two actors are less dependent on other actors in this application process, the acquirer and terminal supplier should try and find incentives for these two actors to cooperate. This will probably be more difficult since in this case the sense of urgency is not divided evenly.

The main goal of this research was also to investigate the potential of using simulation and modeling as a method to improve performance of a complex network consisting of many, interdependent actors We have demonstrated that such a complex system indeed needs other policy measures than optimization within one company, and that the simulation model was able to show where to find the interdependencies between the companies and how this could affect the policy measures. More researches are needed to provide recommendations in using simulation and modeling to improve business system performance, however, the modeling process presented in this study may be applicable to a comparable process.

6 Recommendations

To further elaborate the research described in this paper, there are a number of fruitful research directions. For example further research about the actual times the processes take in the real life is a good option to start with, this way the current behavior can be taken into account. Discrete-event simulation tools like Arena are very suitable for this application since it involves a business system which involves many queues within the network, and the activities are distributed irregularly in time (DeBenedictis et al., 1991). Further research about the variance within the data can also be interesting, to analyze how lean the process is and which implications this has for the system performance. Also, further research could be done into the input of the actual numbers of merchant and capacities of the companies to see variations in different companies.

Approaching this business system from another perspective, it could be interesting to find out the wishes and perspective of the merchant, to figure out which values of throughput times and number of tasks are acceptable. Interviews and data analysis are needed for this research.

Finally, if a company has the wish to optimize its system performance, further research about the effects of policy measures of companies could be conducted, to find out how these could improve the overall system behavior. Instead of finding these possible improvements manually, it is also becoming increasingly common to couple simulation models to optimization tools that will calculate the optimal parameters within the business system. By combining a simulation model with the current values with such an optimization tool the decision making can be supported and improved for the entire chain of actors (Wiedemann & Kung, 2003). It must be aware though that in this case the opportunistic behavior of actors will obviously be very difficult to incorporate in such an optimization model.

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